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A survey of grassland Asilidae (Diptera) at Queen Elizabeth Park, Pietermaritzburg, South Africa

by

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ABSTRACT

A twelve month survey of adult predatory flies of the family Asilidae (robber flies) inhabiting a Mistbelt/Ngongoni Veld grassland in the KwaZulu Natal Midlands yielded twenty species, including an undescribed genus. Species were divisible into four main groups corresponding closely with the four seasons. Factors likely to be important in determining asilid presence, and assemblage composition, probably include the structural complexity of the grassland. An average of only 12 % of the total fauna was collected per sample, emphasising the importance of comprehensive, focused, single locality surveys.

INTRODUCTION

With well over 1000 afrotropical species in over 100 genera (Oldroyd 1980), the Asilidae probably constitute the most diverse and arguably the most important group of predatory insects in this region. They inhabit virtually all terrestrial biomes and, although probably reaching their greatest diversity and dominance in arid environments, are also a significant component of extensive and important ecosystems such as those found in grassland and woodland biomes (Londt 1994*b*). As major predators of virtually all other insect groups (Londt 1990 1994*b*) they almost certainly have the potential to be important biodiversity indicators, and as such could prove valuable in the formulation of effective biodiversity conservation strategies.

Current knowledge of afrotropical asilids is largely confined to the taxonomy of the group, but even within this discipline additional revisionary work is required. With the rapid development of our taxonomic understanding of the family, which has gone hand-in-hand with concerted efforts to sample the fauna, much additional knowledge has been accumulated. Distribution patterns and phenological data for many species are gradually emerging, although much of this information, contained primarily in the numerous papers by Londt, published over the last 25 years, is based on historic data that requires verification. Similarly, specific phenologies have been established using data gathered from the entire range of the species involved, and while useful, these probably do not adequately reflect what may be true at any one locality. Efforts have been made to accumulate and analyse the food (= prey) requirements of asilids, and to attempt to classify species according to the environments inhabited by imagoes (Londt 1994*b*). Apart from the descriptions of the eggs and early instar larvae of a few species, and speculative comments on their life histories (see Londt & Harris 1987 and Londt 1991), almost nothing is known about the immature stages of afrotropical asilids. According to studies undertaken in other zoogeographical regions larvae are, like the imagoes, also predaceous, feeding predominantly on subterranean coleopterous larvae (Lavigne, Dennis & Gowan 1978; Musso 1981 1983), and so it may be presumed that this is true for afrotropical species. As is the case for the vast majority of invertebrates, insufficient data makes it impossible to assess the conservation status of any of the species.

In an effort to increase our rather limited knowledge base, it was decided that a focussed, year-long study of asilids at a single locality would be useful in gaining some basic insights into the dynamics which must exist within a particular assemblage of asilids. Overall objectives for the study were broad, but included establishing the number of species one might expect to find at a single locality, and what the adult flight periods for each was. Historic phenological data for species, across their distributional ranges, suggest that they may well have different flight periods, but data for a single site would confirm this assumption. In addition it was hoped to gain insights into the possible threat which might be posed by the burning of grassland during the winter months (a common grassland management practice). Although the results of the one year study reported here are preliminary, they appear to represent the first data of their kind from the region.

MATERIALS AND METHODS

Choice of study site

A grassland situation within Queen Elizabeth Park (QEP), Pietermaritzburg, was chosen as the study site for a number of reasons, the main ones, in no specific order, being:

- This vegetation type lends itself to simple, yet effective, standardised sampling of asilid flies.
- This biome is particularly important from a management perspective as large tracts, especially in the KwaZulu-Natal (KZN) Midlands, are currently being turned over to forestry.
- This biome is considered somewhat neglected in terms of the sampling of predatory insects like Asilidae, and indeed insects in general.
- Queen Elizabeth Park is managed by KwaZulu-Natal Wildlife (KZNW), and is the site of this provincial conservation body's headquarters. The park is therefore likely to retain its character for the foreseeable future and so be available for any follow-up studies which may be planned.

Description of QEP study site

QEP (Fig. 1) lies approximately 10 km north of Pietermaritzburg's central business area and consists of six main vegetation types (Le Roux 1988) – *viz.* mixed scrub; exotic plantations (these now being gradually eradicated); lawns (i.e. regularly mowed picnic sites and gardens around KZNW buildings); indigenous bush (= thicket); woodland; and grasslands. Harrison (1996/97) suggested that the grassland can be classified according to Acocks' (1988) classification as transitional between Mist Belt Ngongoni Veld (veld type 45), Ngongoni Veld (type 5) and Southern Tall Grassland (type 65). The predominance of *Aristida junciformis* at the study site would, in my opinion, tend to exclude the Southern Tall Grassland component. This Veld Type, classified by Camp (1997) as Bioresource Group (BRG) 5 (i.e. Moist Midlands Mistbelt), is discussed by Scott-Shaw (1999) who states that 70 % of this BRG is found in KwaZulu-Natal. Seventy percent of this BRG has apparently been transformed and only 1 %

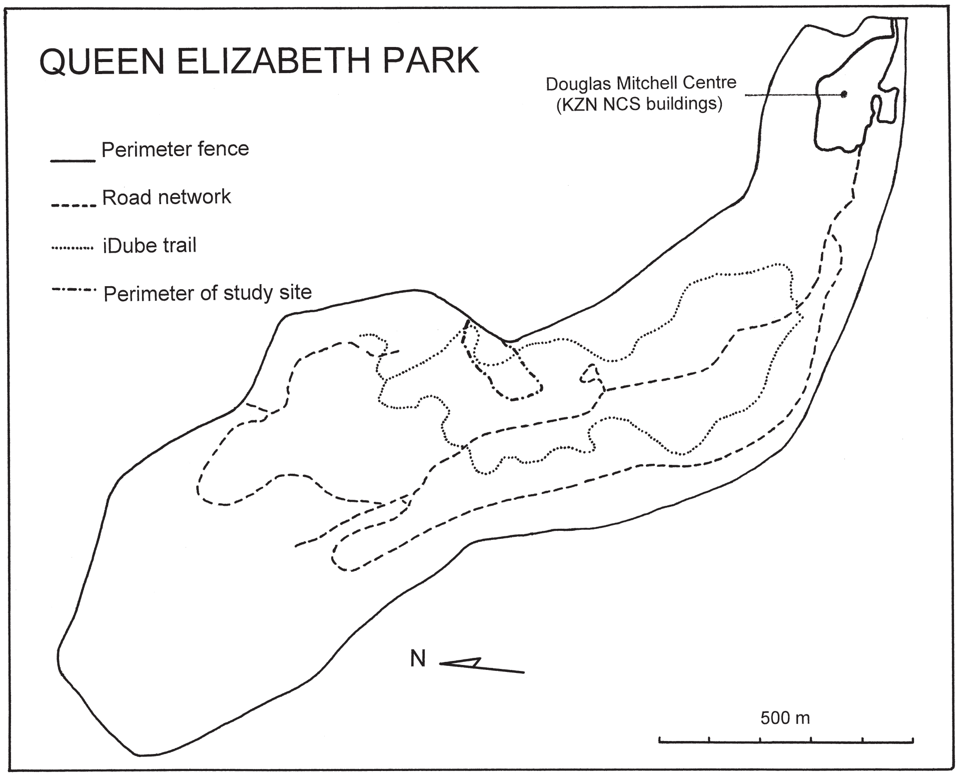

Fig. 1. A map of Queen Elizabeth Park showing the position of the study site and other major features.

occurs in proclaimed protected areas. Clearly there is a special need for information pertaining to this threatened BRG.

An area of mixed grassland, approximately 100 x 200 m (i.e. 20000 m^2), and situated near the centre of the park near a common boundary with the Victoria Country Club's golf course, was selected (Fig. 2). This site, flanked by a forest patch (on the south side) and a wooded area (on the north side), was close to a public parking area and easily accessed by a concrete path (part of the park's iDube trail) which zigzags through the centre of the study site. A GPS reading taken at the centre of the site was 29°34'00"S, 30°19'14"E, 900 m (a.s.l.) altitude.

The study site falls within QEP management block 13, and KZNW kindly refrained from burning this section of grassland during the survey period as this could have unnecessarily complicated the analysis of data. It would, however, be interesting to look at the effects of burning in a future study, as this is apparently a regular management practice at the park.

In an attempt to characterise the study area botanically, samples of the vegetation were regularly taken throughout the study period and identified by means of the following standard texts: Van Oudtshoorn (1999) – grasses; Pooley (1993 1998) – trees and wild flowers respectively. The fairly lengthy list, which is not exhaustive, is provided in Appendix 1 and serves to illustrate the botanical richness of the site. No fewer than 20 grass species were found, these being dominated by *Aristida junciformis* (Ngongoni

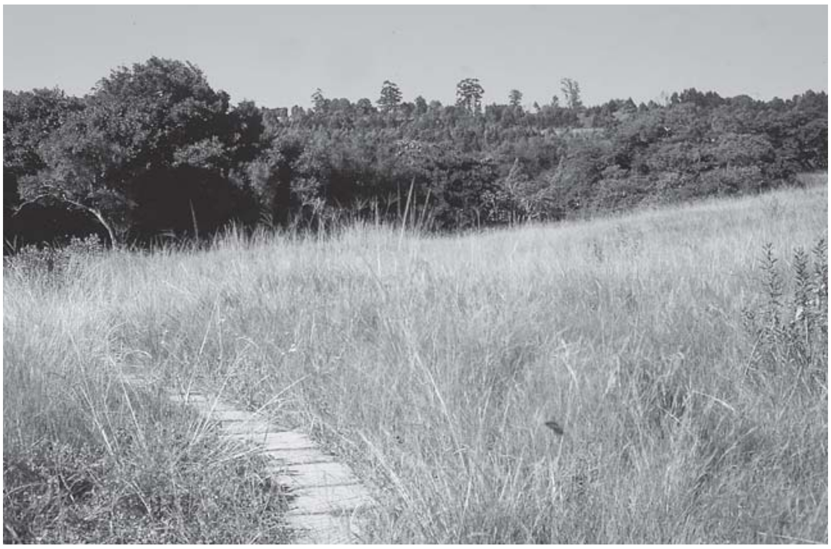

Fig. 2. The Queen Elizabeth Park study area, photographed from the eastern end of the site, facing in a south westerly direction.

Three-awn or Wire Grass) and good stands of *Digetaria eriantha* as well as *Sporobolus africanus*, *S. pyramidalis* and *Hyparrhenia hirta*. In discussing the distribution of South African grasses, Gibbs Russel *et. al.* (1991) state that KZN is dominated by the Panicoideae. This observation is supported by the species composition of the QEP site. Most of the trees (primarily small saplings) and flowers were usually represented by relatively few specimens scattered throughout the area.

General climatic conditions

Although Scott-Shaw (1999) provides a brief description of the climatic conditions associated with Mist Belt Ngongoni Veld (= Moist Midlands Mistbelt), details of the climatic conditions that prevailed during the QEP survey period are considered worthy of recording. As rainfall data collected at QEP are incomplete, daily readings taken at my suburban home in Athlone (about 4 km south of the QEP site) are used to reflect conditions in the park. Rainfall data for the period of the survey are presented graphically in Fig. 3, the total recorded for the year 2000 being 896 mm. The precipitation pattern is typical for the area and, dividing the year into four equal seasons centred on solstices and equinoxes, includes a dry winter (weeks 19–31) when virtually no rain falls, followed by a spring (weeks 32–44) when light rains are the norm (occasional heavy downpours may be experienced). Summer (weeks 45–5) is wet (characterised by thundershowers), followed by a gradual decrease in rainfall during autumn (weeks 6–18). Temperature data are not available for the study area and were not recorded at my home. However, records maintained at the nearest weather station (Cedara Agricultural College), 10 km from QEP, were used to generate the graphs provided in Fig. 3. While Cedara is at a higher altitude and known to be generally cooler than QEP, the graphs provide a general indication of conditions that would have been experienced at QEP during the study period. The graph shows that mean weekly maxima were commonly over 25°C during

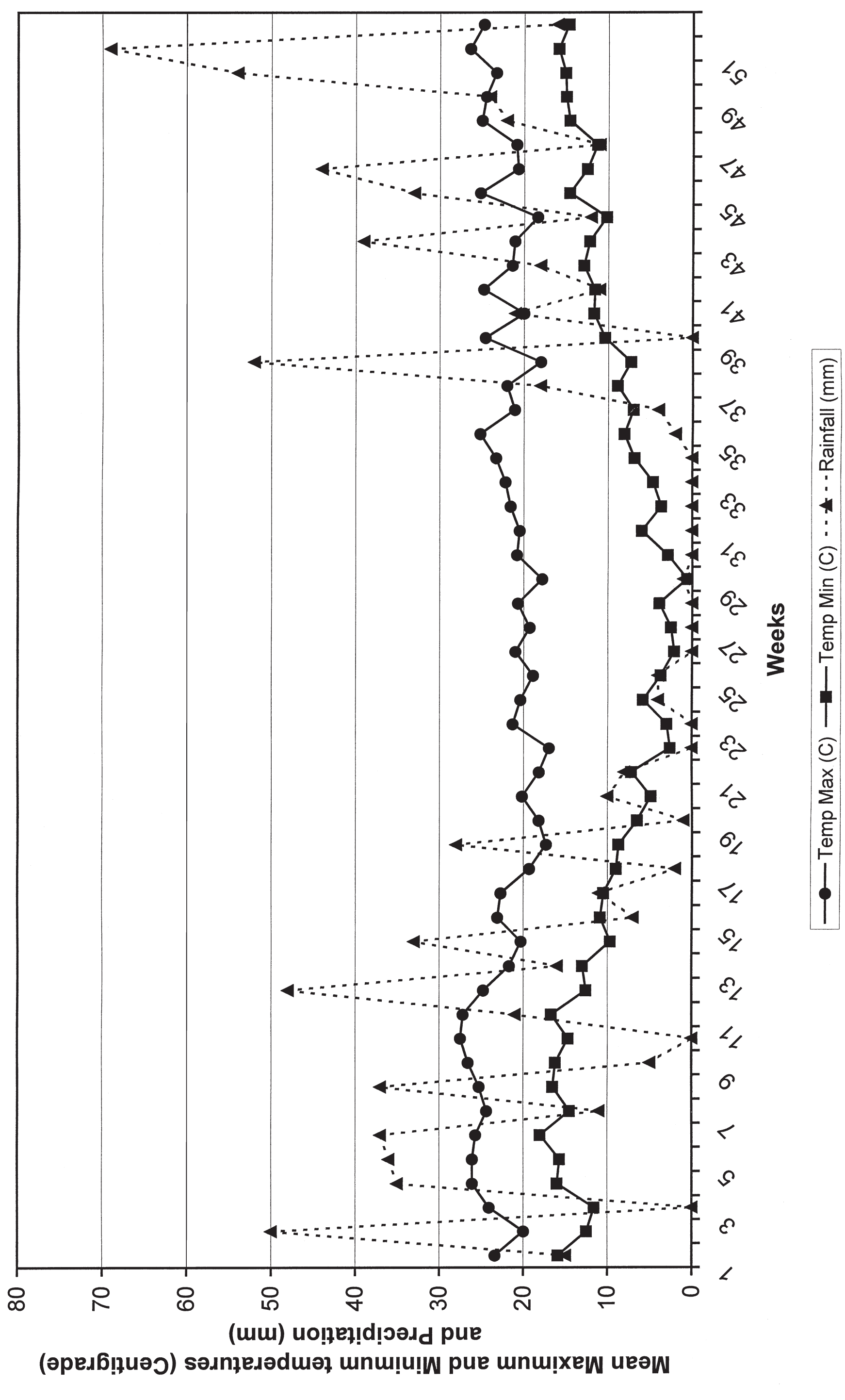

Fig. 3. Temperature data (mean weekly maxima and minima in °C), as collected at Cedara Agricultural College, and rainfall data (mean weekly in mm) collected at Athlone near the Queen Elizabeth Park study site.

the latter part of summer (34·0°C being the highest daily maximum – recorded 19 December), and that averages did not fall below 17°C during winter (lowest daily maximum being 9·1°C – recorded 18 September). As far as minima are concerned, the average weekly minimum fell below 5°C for a number of weeks over mid-winter (the lowest daily minimum being 2·7°C – recorded 21 July). Mean weekly minimum temperatures were commonly above 15°C during the latter part of summer (highest daily minimum being 21 0°C – recorded 13 December).

Sampling methods and period of survey

Sampling was undertaken using a sturdy sweep-net with a diameter of 30 cm. Vegetation was swept for a period of one hour weekly throughout the year 2000. A 'week' was taken as commencing on a Monday and terminating on a Sunday. The first sample, taken on 1 January 2000, fell into week 52 of 1999, while the final sample, taken on 7 January 2001, fell into week 1 of 2001. In two instances, two samples were made during the same week (weeks 3 and 14), the data for these samples being combined, while on three occasions (weeks 8, 50 and 51) it was not possible to take samples.

Sampling involved sweeping the insect net through the vegetation while slowly walking around the study area visually scanning the vegetation for larger asilids that might otherwise have escaped the net. Care was taken not to sample vegetation within two metres of the adjacent wooded areas. The contents of the net were examined at frequent intervals and captured asilids either transferred to a killing bottle (usually a maximum of four specimens – two of each sex – per species, per sampling occasion) or identified, counted (from week 9) and released. In this way a collection was accumulated for study in the laboratory and to store in the Natal Museum's permanent collection (i.e. as voucher specimens), without unnecessarily depleting population numbers. Although there was always the possibility of recapturing released specimens, this was not considered problematic as interest was focussed on qualitative rather than quantitative data. All sampling was undertaken by me to provide a measure of standardisation. As it is well known that weather conditions influence insect activity, every effort was made to sample at times when it was sunny and warm. The majority of collections were made during the late morning (from about 11:00 – 12:00), but this was not always possible, and early afternoon collections were sometimes unavoidable.

RESULTS AND DISCUSSION

Twenty asilid species were encountered during the survey (Table 1) and Fig. 4 summarises the findings. Species were assigned numbers when first collected, and these are used from time to time in this paper. Fig. 4 illustrates both the progressive discovery of species as well as the periods they were active. Although captured asilids were counted (from week 9), no attempt to portray the relative abundance of species was attempted in Fig. 4. The main reason for this is that weekly sample size for most species was usually less than four specimens, except for species 1, 2, 3 and 20 when larger numbers were frequently (species 2) or occasionally recorded. A useful discussion of species abundance is, therefore, not considered possible.

Notes on the 20 species encountered are provided in Table 1. These are confined to a listing of the subfamily to which the species belongs, brief indications of the adult habitat and probable oviposition strategy employed (based on observation and/or ovipositor structure), an indication of overall abundance and any useful references to the species. Very little is known about the biology of any of the species involved. No effort was made to establish the geographical ranges of the species, although for a few species information of this kind has been published. Such work may be a worthwhile undertaking at a later date, in order to estimate the possible value of the QEP reserve in the conservation of each species encountered during this survey.

Species composition

A subfamily analysis of the QEP species (Table 1) indicates that with seven species, the Apocleinae were best represented. This was followed by the Stenopogoninae with four species and the Leptogastrinae with three. Both the Ommatiinae and Trigonomiminae were represented by two species, while only a single species of each of the Asilinae and Dasypogoninae was found. The Laphriinae, Laphystiinae and Stichopogoninae were absent from the assemblage. Representatives of a few genera known to occur in grassland situations in and around Pietermaritzburg, were not encountered (e.g. species of *Damalis* and *Gonioscelis*).

Identification of the asilids to species level was possible for 11 of the 20 species found. While one species appears to belong to an as yet undescribed genus, related to both *Dasophrys* and *Neolophonotus*, all the other unidentified species belong to well-known, but incompletely studied genera. *Euscelidia* is currently receiving attention by Mr Torsten Dikow, who will soon be able to give the QEP species a name. *Afroholopogon* is a genus with about a dozen described species, but needs modern revision. It is anticipated that some new species will need description. Until this work is done, names will not be available for the two species found at QEP. *Leptogaster* is a big genus with 76 species listed by Oldroyd (1980). These small flies are taxonomically difficult and in need of modern revision. Until this has been undertaken, it will not be possible to confidently put names to the two QEP species. This leaves two species of *Promachus* and a *Microstylum* without specific names. Both these genera are large, with 88 and 79 species respectively (Oldroyd 1980), and also need revision before names can confidently be provided.

Although taxonomists working with invertebrates are well aware of the paucity of knowledge about them, the point still needs to be made that, despite their relatively high profile (i. e most entomologists can recognise members of the family), the Asilidae remain inadequately studied taxonomically.

Phenology

Four main groups of QEP grassland asilids may be recognised based on adult activity periods, and these conveniently fall reasonably neatly into the four seasons as defined in this study. An appreciation of these groups is perhaps best achieved by referring to Fig. 4.

- *Summer species*: These include species which emerge in late spring or early summer and persist for many weeks, finally disappearing from samples with the onset of winter (i.e. species 1–3). These persistent species were not only present for much of the year, but possessed the highest population densities. Also considered ‘summer species’ are species 4 & 5 which, based on available evidence, appear to have relatively short flight periods in late summer, and species 19 & 20, which were active for similarly short periods in early summer. Species 8 (*Pegesimallus calvifrons*) is

Fig. 4. Asilid survey results obtained at Queen Elizabeth Park.. Abbreviations: A = Autumn, S = Summer, SP = Spring, W = Winter, Sp. = Number of species collected, % = Percentage of known species from the site. Note: There are two different reasons for the complete absence of asilids on six occasions – No samples were taken on weeks 8, 50 and 51, whilst no asilids were found in samples taken during weeks 32, 37 and 38.

Species	Present in sample ●; - absent from sample; ◆ no sample taken																										
1	●	●	●	●	●	●	●	●	◆	●	●	●	-	-	-	-	●	-	-	-	-	-	-	-	-	-	-
2	●	●	●	●	●	●	●	●	◆	●	●	●	●	●	●	●	●	●	●	●	●	-	-	-	-	-	-
3	●	●	●	●	●	●	●	●	◆	-	●	●	●	-	-	-	-	-	●	-	-	-	-	-	-	-	-
4	-	●	●	●	●	●	-	-	◆	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5	-	-	-	●	-	●	-	-	◆	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6	-	-	-	-	-	-	●	●	◆	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7	-	-	-	-	-	-	-	-	◆	●	-	●	●	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8	-	-	-	-	-	-	-	-	◆	●	-	●	●	-	●	●	-	-	-	-	-	-	-	-	-	-	-
9	-	-	-	-	-	-	-	-	◆	-	●	-	-	●	-	-	●	-	-	-	-	-	-	-	-	-	-
10	-	-	-	-	-	-	-	-	◆	-	●	●	●	●	-	-	-	-	-	-	-	-	-	-	-	-	-
11	-	-	-	-	-	-	-	-	◆	-	-	●	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
12	-	-	-	-	-	-	-	-	◆	-	-	-	-	●	-	-	-	-	-	-	-	-	-	-	-	-	-
13	-	-	-	-	-	-	-	-	◆	-	-	-	-	-	-	●	-	-	-	-	-	-	-	-	-	-	-
14	-	-	-	-	-	-	-	-	◆	-	-	-	-	-	-	-	-	-	●	-	-	-	-	-	-	-	-
15	-	-	-	-	-	-	-	-	◆	-	-	-	-	-	-	-	-	-	-	●	●	-	-	-	●	-	-
16	-	-	-	-	-	-	-	-	◆	-	-	-	-	-	-	-	-	-	-	-	●	●	●	●	●	●	●
17	-	-	-	-	-	-	-	-	◆	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
18	-	-	-	-	-	-	-	-	◆	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
19	-	-	-	-	-	-	-	-	◆	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
20	-	-	-	-	-	-	-	-	◆	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Week	52	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
Sp.	3	4	4	5	4	5	4	4	-	4	5	7	5	4	2	3	3	1	3	2	3	1	1	1	2	1	1
%	15	20	20	25	20	25	20	20	-	20	25	35	25	20	10	15	15	5	15	10	15	5	5	5	10	5	5
Season	**S**	**S**	**S**	**S**	**S**	**S**	A	A	A	A	A	A	A	A	A	A	A	A	A	**W**	**W**	**W**	**W**	**W**	**W**	**W**	**W**

Species	Present in sample ●; - absent from sample; ◆ no sample taken																										
1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	◆	◆	●	●
2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	●	-	◆	◆	●	●
3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	●	●	●	●	-	●	●	●	●	◆	◆	●	●
4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	◆	◆	-	●
5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	●	●	◆	◆	●	●
6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	◆	◆	-	-
7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	◆	◆	-	-
8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	●	-	-	●	-	-	-	●	◆	◆	-	-
9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	◆	◆	-	●
10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	◆	◆	-	-
11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	◆	◆	-	-
12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	◆	◆	-	-
13	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	◆	◆	-	-
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15	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	◆	◆	-	-
16	●	●	●	●	●	-	●	●	●	●	-	-	-	-	-	-	-	-	-	-	-	-	-	◆	◆	-	-
17	-	-	-	-	-	-	-	●	-	-	-	-	-	●	-	-	●	-	●	-	-	-	-	◆	◆	-	-
18	-	-	-	-	-	-	-	-	-	-	-	-	●	-	-	-	-	-	-	-	-	-	-	◆	◆	-	-
19	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	●	-	●	-	●	◆	◆	-	-
20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	●	●	●	●	●	◆	◆	-	-
Week	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	1
Sp.	1	1	1	1	1	0	1	2	1	1	0	0	1	1	1	2	2	1	4	2	3	4	5	-	-	4	6
%	5	5	5	5	5	0	5	10	5	5	0	0	5	5	5	10	10	5	20	10	15	20	25	-	-	20	30
Season	W	W	W	W	W	SP	SP	SP	SP	SP	SP	SP	SP	SP	SP	SP	SP	SP	S	S	S	S	S	S	S	S	S

problematic as data seem to suggest two periods of activity; however as collections were usually small and infrequent, it is probable that the species, usually associated with forest margins, may be present from late spring through to late autumn.
- *Autumn species*: These include nine species (6–14) which have relatively short flight periods in autumn (weeks 6–18) when the grass sward is at its peak of development. Species 15, with a flight period of some six weeks, may also be included in this group, although its flight period was actually during the early winter weeks (weeks 19–24).
- *Winter species*: Excluding species 15, which is perhaps more appropriately considered with the autumn species, species 16, *Neolophonotus wroughtoni*, is the only species with a truly winter flight period. The species disappeared from samples with the commencement of spring rains.
- *Spring species*: Although data are limited, species 17 (*Leptogaster* sp. 2) appears to have a flight period restricted to spring (weeks 34–45). The single record for species 18, collected in week 39, may also suggest that this is a spring species, but data are inadequate.

Factors determining adult activity periods are poorly understood. However, some speculation relating to them is considered appropriate.

The three dominant summer species (1–3) are obviously well adapted for life in the area studied, and as they are all of a similar size and appear to inhabit the same microhabitats (i.e. they were frequently found together in the net), they may well compete with each other for prey (no prey records were obtained as the sampling method was not conducive to the gathering of such data). Competition for oviposition sites, however, is unlikely as all three have a different ovipositor morphology (and therefore probably different oviposition strategies – Table 1). All three appear to respond similarly to abiotic factors determining phenology. A more detailed study of these dominant species would assist in understanding the dynamics of interactions that almost certainly take place between them.

Species 4, 5, 19 and 20, included under summer species, are rather different from the three dominant species mentioned above. They have much shorter periods of adult activity and population densities were low (characteristics common to autumn species – see below). Species 4 and 5, although active during late summer, may be more appropriately discussed with autumn species, while species 19 and 20 cannot really be considered along with autumn species as the grassland environment is somewhat different during the early summer. Species 19 (*Microstylum* sp.) is large and capable of ranging over extensive areas of relatively short early summer vegetation, and so is rather different from the other species considered above.

The group of autumn species is the largest component, species assigned to this group (6–14 and probably 15) being characterised by relatively short flight periods (up to 7 weeks) and low population densities (samples of less than 4 individuals per week). As suggested above, summer species 5 and 6 share these characteristics along with species 15 which has an early winter flight period. The reason why grassland is able to sustain so many species during the autumn (15, if the three dominant summer species are included) may be a direct consequence of the state of the vegetation, and in particular the grasses. It is during the autumn that many grasses set their seed and are generally at their best in terms of height and density,

TABLE 1

The asilid species sampled in grassland at Queen Elizabeth Park, arranged in the order in which they were found

No	**Species**	**Subfamily**	**Adult habitat**	**Oviposition behaviour**	**Notes and useful references**
1	Species X	Apocleinae	Open grassland (within)	Eggs pasted between grass leaves[1]	Abundant. Undescribed genus nr. *Dasophrys*
2	*Caenoura annulitarsis* (Loew, 1858)	Asilinae	Open grassland (within)	Eggs laid in grass crevices*	Abundant. Tsacas (1969), Londt 2002
3	*Euscelidia* sp.	Leptogastrinae	Open grassland (within)	Eggs dropped randomly*	Moderately numerous. Janssens (1957), Oldroyd (1974)
4	*Afroholopogon* sp. 1	Stenopogoninae	Open grassland (canopy)	Eggs laid directly into soil*	9 specimens. Oldroyd (1974), Londt (1994*a*)
5	*Rhipidocephala obscurata* Oldroyd, 1966	Trigonomiminae	Open grassland (canopy)	Eggs dropped randomly*	2 specimens. Oldroyd (1966)
6	*Ommatius chiastoneurus* Speiser, 1910	Ommatiinae	Open grassland (within)	Eggs dropped randomly*	2 specimens. Scarbrough identification. Genus being revised
7	*Neolophonotus albopilosus* (Ricardo, 1920)	Apocleinae	Open grassland	Eggs laid directly into soil*	5 specimens. Londt (1985)
8	*Pegesimallus calvifrons* Londt, 1980	Dasypogoninae	Grass adjacent to forest patch	Eggs laid directly into soil*	11 specimens. Londt (1980)
9	*Leptogaster* sp. 1 (nr *maculipennis* Janssens, 1957)	Leptogastrinae	Open grassland (within)	Eggs dropped randomly*	4 specimens. Identification uncertain. Genus needs revision
10	*Promachus* sp. 1 (*fasciatus* sp. group)	Apocleinae	Grass adjacent to woodland	Eggs laid directly into soil*	7 specimens. Oldroyd (1974)
11	*Rhipidocephala caffra* (Macquart, 1846)	Trigonomiminae	Open grassland (canopy)	Eggs dropped randomly*	1 specimen. Oldroyd (1966)
12	*Dasophrys fortis* Londt, 1981	Apocleinae	Open grassland	Eggs laid in crevices in woody plants*	1 specimen. Londt (1981)
13	*Rhabdogaster rusticus* Oldroyd, 1974	Stenopogoninae	Open grassland (canopy)	Eggs laid directly into soil*	1 specimen. Oldroyd (1974)
14	*Dasophrys androclea* (Walker, 1849)	Apocleinae	Grass adjacent to woodland	Eggs laid in woody plants and grass crevices[1]	1 specimen. Londt (1981)
15	*Afroholopogon* sp. 2	Stenopogoninae	Open grassland (canopy)	Eggs laid directly into soil*	5 specimens. Oldroyd (1974)
16	*Neolophonotus wroughtoni* (Ricardo, 1920)	Apocleinae	Open ground & concrete path	Eggs laid directly into soil[1]	Moderately numerous. Londt (1988)
17	*Leptogaster* sp. 2	Leptogastrinae	Open grassland (within)	Eggs dropped randomly*	6 specimens. Genus needs revision
18	*Promachus* sp. 2 (nr *amastrus* (Walker, 1849))	Apocleinae	Concrete path	Eggs laid directly into soil*	1 specimen. Genus needs revision
19	*Microstylum* sp.	Stenopogoninae	Open grassland	Eggs laid directly into soil*	5 specimens. Genus needs revision
20	*Ommatius terminalis* Bromley, 1936	Ommatiinae	Open grassland	Eggs dropped randomly*	23 specimens. Oldroyd (1974)

[1] - Observed during this study

* - Assumption based on form of ovipositor (see Londt 1994*b*)

and so it is possible that they not only sustain a greater diversity and abundance of insect life (= asilid prey), but that a greater diversity of micro-habitats (= territories and oviposition sites) are available. It is worth recording that it was during the autumn that sweep-net samples contained the greatest abundance and diversity of insects in general; however, except for the asilids, these were not studied in any way. Although there are many autumn species, it should be noted that flight periods do not always overlap and that, of the 14 species collected during autumn (i.e. weeks 5–18), excluding the three dominant summer species (1–3), samples never contained more than 5 species within the autumn species group. This may indicate the existence of subgroups within this group.

The winter group comprises essentially only species 16 (*Neolophonotus wroughtoni*). This species does not appear to have any direct association with grassland in the adult stage. Individuals were never found in sweep-net samples, but always observed, and netted, as they rested on concrete paving slabs or on the few large stones within the grassland area. The species is an active flier, able to range over considerable distances, and so has good access to prey at a time when insect population levels are generally low. The fact that adults are efficient fliers and do not appear to utilise vegetation in any way, means that the assumption that larvae live in soils associated with grasslands is not necessarily correct, although oviposition in loose sand near paving slabs was observed. The adult flies are well adapted for activity during the cooler winter months by being black (to absorb heat) and by having orientation behaviour designed to expose the largest possible surface area of the body to the direct rays of the sun. A well-developed thoracic mane and mystax effectively increases the surface area of the insect in lateral view. While it may be easy to imagine that the onset of a rainy season could stimulate the emergence of certain insects, it is more difficult to imagine how warmer, wetter conditions might signal an end to *N. wroughtoni*'s adult phase. More research into such matters is required.

The only species included in the spring species group is *Leptogaster* sp. 2 (species 17). It was first collected in week 34, which coincides almost exactly with the first spring rains (Fig. 3), and was collected for the last time in the cycle on week 45, which marks the first week of summer. In some respects it is strange that a *Leptogaster* species should fly at this time of year as the grass is generally dry, bent and broken; the only green parts being short, new growth. Species of *Leptogaster* are usually considered well adapted for life within long, vertically orientated grass stems typified by late summer and autumn conditions.

It is important to note that some of the species encountered in the QEP grassland may not in fact be grassland species. Species found in low numbers and on few occasions may be species more commonly associated with other vegetation types in the area (i.e. woodland or forest), or with ecotones. Species which are probably not truly adapted for life in grasslands (i.e. 10, 12, 14, and possibly 8) should perhaps to considered to be 'in transit' between patches of their more usual habitat. Further work in the adjacent woodlands and forest would compliment the present findings, and should be undertaken.

Factors determining the composition of a grassland asilid fauna

While much more work is necessary before any kind of predictive model can be generated, some general comments regarding the factors which may play a role in determining asilid species presence and assemblage composition in grasslands, may provide guidelines for the planning of future research.

Climatic/abiotic factors:

It is certain that the many abiotic factors that combine to produce the macro-climatic conditions suitable for the existence of grassland, and the micro-habitats associated with this vegetation type, have a role to play in determining the presence and relative abundance of asilid species. Consequently, it is unlikely that any two study sites will ever be exactly the same in terms of species composition and relative population densities. While I am not able to discuss in detail the role that abiotic factors may have on asilids, it is perhaps worth considering briefly the role of fire, as burning probably has an important impact on insects adapted for life in grass (Chambers & Samways 1998).

The burning of grass, either accidental or deliberate (as part of a management strategy), is likely to have at least a short-term adverse effect on grassland insects in general, and on the Asilidae in particular, if the timing corresponds with peak periods of adult activity. Data presented in this paper suggest that mid-winter fires are likely to have the least impact on asilid populations in QEP. The only species present during much of winter (*Neolophonotus wroughtoni*) is widespread and has the ability of powerful flight. It is also probable that individuals emerged throughout the many weeks the species was encountered, suggesting that many of the subterranean larvae and pupae are likely to survive the adverse effects of grass burning.

Biotic factors:

While most of the biotic factors important in determining ecological interactions featuring grassland asilids are likely to be dependent on climatic and other abiotic factors, it may be useful to consider some of the more obvious biotic factors that could be involved, apart from the availability of prey.

In the same way that 'plant growth-form' has been demonstrated to be of importance in providing 'shelter' to terrestrial invertebrates (Bossenbroek *et. al.* 1977 *a,b*), it is probable that the structure of any grassland is more important to asilids than its floral composition. For predatory insects that are less likely to develop very specific interactions with particular plant species, factors such as the availability of suitable perches, prey, and sites for oviposition are likely to be important determinants both of species presence and abundance within any vegetation type. In other words, the *structural complexity* of a grassland is likely to be an important factor influencing asilid diversity and population density. As the QEP study site supports a wide variety of grasses and associated flora (see Appendix 1), it is probable that a concomitantly wide range of micro-habitat types and plant growth-forms are available for exploitation by asilids. Grassland asilid species are generally small and are therefore probably well adapted to life in relatively small micro-habitats. Grasslands of low floral diversity, and therefore of more simple structure, may be expected to accommodate fewer than the twenty species found at QEP. As no comparative studies have been undertaken, such statements are largely conjecture and need support through investigation.

The fact that various workers have attempted to classify Asilidae according to the nature of the habitats in which they have been observed (Lehr 1979; Fisher &

Hespenheide 1992; Londt 1994*b*) supports the validity of the statements made above. However, it should be noted that there may be a few asilid species that require very specific conditions that may only be provided by particular plant species. Possible examples are *Neolophonotus dichaetus* Hull, 1967, that utilises the pinnate leaves of certain trees in its oviposition behaviour (Londt & Harris 1987), and Species X in the present study that was observed using grass leaves for similar purposes.

Surveying grassland Asilidae

If the percentage of species encountered weekly at QEP is examined against time (Fig. 4), a number of facts emerge. Firstly it is evident that the best time for the collection of asilids is late summer and throughout much of the autumn when more than 20 % (4 species) of the total asilid fauna may be sampled during any particular week. Secondly it may be seen that at best only 35 % (7 species) are likely to be collected on any single occasion (i.e. week 11 of the survey). The present survey results suggest that at least 5 % (1 species) of the fauna is always likely to be present and it may be calculated that, on average, 12·5 % (2·5 species) of the total asilid fauna was collected weekly. These facts make the point that localities sampled only once (a common phenomenon), are likely to be greatly underestimated with respect to the assemblage of species that actually live there. This should be taken into consideration when planning biodiversity surveys.

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REFERENCES

Acocks, J. P. H. 1988. Veld types of South Africa (3rd Edition). *Memoirs of the Botanical Survey of South Africa* No. 57. Botanical Research Institute, South Africa.

Bossenbroek, P., Kessler, A., Liem, A. S. N. & Vlijm, L. 1977*a*. The significance of plant growth forms as 'shelter' for terrestrial animals. *Journal of Zoology* **182**: 1 6.

1977*b*. An experimental analysis of the significance of tuft structures as a shelter for terrestrial invertebrate fauna, with respect to wind velocity and temperature. *Journal of Zoology* **182**: 7 16.

Camp, K. G. T. 1997. The bioresource groups of KwaZulu Natal. Natural Resource Section. Report No. N/A/97/6. Cedara: KwaZulu Department of Agriculture.

Chambers, B. Q. & Samways, M. J. 1998. Grasshopper response to a 40 year experimental burning and mowing regime, with recommendations for invertebrate conservation management. *Biodiversity and Conservation* **7**: 985 1012.

Fisher, E. M. & Hespenheide, H. A. 1992. Taxonomy and biology in Central American robber flies with an illustrated key to genera. *In*: Quintero, D. & Aiello, A., eds, *Insects of Panama and Mesoamerica: selected studies*. Oxford: Oxford University Press pp. 611 632.

Gibbs Russell, G. E., Watson, L., Koekemoer, M., Smook, L., Barker, N. P., Anderson, H. M. & Dallwitz, M. J. 1991. Grasses of southern Africa. National Botanical Gardens & Botanical Research Institute, South Africa.

Harrison, P. [undated probably 1996 or 7]. *Current veld assessment and grazing capacity rates for Queen Elizabeth Park Nature Reserve*. Unpublished report, KwaZulu Natal Conservation Service, Pietermaritzburg.

Janssens, E. 1957. Contribution à l'étude des Leptogastrinae (Diptera Asilidae). *Bulletin de l'Institut Royal des Sciences Naturelles de Belgique*. **33** (49): 1 12.

Lavigne, R., Dennis, S. & Gowen, J. A. 1978. Asilid literature update 1956 1976: including a brief review of robber fly biology (Diptera: Asilidae). Laramie: University of Wyoming, Agricultural Experiment Station. (Science monograph; 36).

Le Roux, Z. 1988. *Physiognomic vegetation types at Queen Elizabeth Park*. Unpublished report, KwaZulu Natal Conservation Service, Pietermaritzburg.

Lehr, P. A. 1979. On the direction of evolution (exemplified by Diptera, Asilidae). *In*: *Studies in evolution: parallelism and divergence*. Proceedings of the Academy of Sciences of the USSR Far Eastern Scientific Centre, Institute of Biology and Pedology. New Series. **52** (155): 20 57. [Text in Russian].

Londt, J. G. H.. 1980. Afrotropical Asilidae (Diptera) 4. The genus *Pegesimallus* Loew, 1858 (= *Lagodias* Loew, 1858; *Neolaparus* Williston, 1889) including species from other zoogeographical regions and the descriptions of two new genera *Brevirostrum* and *Caroncoma*). *Annals of the Natal Museum* **24** (1): 233 347.

1981. Afrotropical Asilidae (Diptera) 5. The genus *Dasophrys* Loew, 1858 (= *Hobbyus* Bromley, 1952) (Asilinae: Asilini). *Annals of the Natal Museum* **24** (2): 635 699.

1985. Afrotropical Asilidae (Diptera) 12. The genus *Neolophonotus* Engel, 1925. Part 1. The *chionthrix*, *squamosus* and *angustibarbus* species groups (Asilinae: Asilini). *Annals of the Natal Museum* **27** (1): 39 114.

1988. Afrotropical Asilidae (Diptera) 15. The genus *Neolophonotus* Engel, 1925. Part 4. The *comatus* species group (Asilinae: Asilini). *Annals of the Natal Mueum* **29** (1): 1 166.

1990. Afrotropical Asilidae: Prey survey of adult flies. *Abstacts of the Second International Congress of Dipterology, Bratislava. August 27 September 1, 1990* p. 134.

1991. Afrotropical Asilidae (Diptera) 21. Notes on the biology and immature stages of *Damalis femoralis* Ricardo, 1925 (Trigonomiminae). *Annals of the Natal Museum* **32**: 149 162.

1994*a*. Afrotropical Asilidae (Diptera) 24. *Afroholopogon*, a new genus for Afrotropical species previously allocated to *Cyrtopogon* Loew, *Heteropogon* Loew and *Holopogon* Loew (Stenopogoninae). *Annals of the Natal Museum* **35**: 61 69.

1994*b*. Afrotropical Asilidae (Diptera) 26. Ethological observations, and a possible ecological classification based on habitats. *Annals of the Natal Museum* **35**: 97 122.

2002. Afrotropical Asilinae (Asilidae): A provisional key to genera, with a review of the status of *Neomochtherus* Osten Sacken, 1878, and descriptions of new genera and species. *African Invertebrates* **43**: 000 000.

Londt, J. G. H. & Harris, M. S. 1987. Notes on the biology and immature stages of *Neolophonotus dichaetus* Hull, 1967 in South Africa (Diptera: Asilidae: Asilinae). *Journal of the Entomological Society of Southern Africa* **50**: 427 434.

Musso, J J. 1981. Morphology and development of the immature stages of some robber flies (Diptera: Brachycera: Asilidae). *Entomologia Generalis* **7** (1): 89 104.

1983. Nutritive and ecological requirements of robber flies (Diptera: Brachycera: Asilidae). *Entomologia Generalis* **9** (1/2): 35 50.

Oldroyd, H. 1966. The genus *Rhipidocephala* (Diptera: Asilidae). *Bulletin of the British Museum of Natural History*. **19**: 145 172.

1974. An introduction to the robber flies (Diptera: Asilidae) of Southern Africa. *Annals of the Natal Museum* **22** (1): 1 171.

1980. Family Asilidae. *In*: Crosskey, R. W., ed., *Catalogue of the Diptera of the Afrotropical Region*. London: British Museum (Natural History) pp. 334 373.

Pooley, E. 1993. *The complete field guide to trees of Natal, Zululand and Transkei*.. Durban: Natal Flora Publications Trust.

1998. *A field guide to the wild flowers of KwaZulu Natal and the Eastern Region*. Durban: Natal Flora Publications Trust.

Scott Shaw, C. R. 1999. *Rare and threatened plants of KwaZulu Natal and neighbouring regions*. KwaZulu Natal Nature Conservation Service, Pietermaritzburg.

Tsacas, L. 1969. Revision des especes du genre *Neomochtherus* Osten Sacken (Diptères: Asilidae). II. Region Ethiopienne. *Mémoires de Muséum National D'Histoire Naturelle*. Série A. Zoologie. **LXI** (1): 1 32.

Van Oudtshoorn, F. 1999. *Guide to grasses of Southern Africa*. Pretoria: Briza.

APPENDIX 1

Vegetation recorded at the Queen Elizabeth Park study site.

Grasses (arranged in subfamilies) (stars represent subjective assessment of relative abundance):
Arundinoideae
Aristida junciformis (Ngongoni Three awn, Wire Grass) *****
Bambusoideae none
Chloridoidea
Eragrostis capensis (Heart seed Love Grass) **
Eragrostis curvula (Weeping Love Grass) *
Eragrostis plana (Tough Love Grass) *
Eragrostis superba (Sawtooth Love Grass) *
Harpochloa falx (Caterpillar Grass) *
Sporobolus africanus (Ratstail Dropseed) ***
Sporobolus pyramidalis (Catstail Dropseed) ***
Panicoideae
Cymbopogon plurinoides (Narrow leaved Turpentine Grass) *
Digetaria eriantha (Finger Grass) ****
Diheteropogon filifolius (Thread leaved Bluestem) *
Hyparrhenia anamesa (Bundle Thatching Grass) *
Hyparrhenia hirta (Common Thatching Grass) ***
Imperata cylindrica (Cottonwool Grass) *
Melinus nerviglumis (Bristle leaved Red Top) *
Monocymbium ceresiiforme (Boat Grass) *
Panicum dregeanum (Plum Panicum) *
Paspalum notatum (Bahia Grass) *
Setaria sphacelata (Golden Bristle Grass) *
Themeda triandra (Rooigras) *
Pooideae none

Sedges:
Kyllinga sp. (? *alata*)
Mariscus sp. (? *congestus*)

Trees and wild flowers:
Ageratum houstonianum (Blue Weed)
Albuca nelsonii (Candlelabrum Lily)
Argyrolobium harveyanum
Aristea woodii (Wood's Aristea)
Athrixia phylicoides (Bushman's tea)
Becium obovatum (Cat's Whiskers)
Berkheya erysithales
Berkheya rhapontica (Ntsoa ntsane)
Ceratotheca triloba (Wild Foxglove)
Crotalaria globifera (Round Pod Rattle Bush)
Cyrtanthus tuckii (Green tipped Fire Lily)
Eriosema cordatum (Heart leaved Eriosema)
Eulophia ensata (iphamba lentaba)
Helichrysum cooperi (Yellow Everlasting)
Helichrysum inornatus (Inkanga)
Helichrysum nudifolium (Hottentot's Tea)
Helichrysum rugulosum (Morotole)
Heliophila rigidiuscula (Grassland Blue Cross Flower)
Hypoxis acuminata
Laggera elata
Lantana camara (Tickberry)
Leonotis leonurus (Wild Dagga)
Monopsis decipiens (Butterfly Lobelia)
Moraea spathulata (Large Yellow Moraea)
Pachycarpus natalensis (Natal Thick fruit)
Pentanisia prunelloides (Broad leaved Pentanisia)
Pseudarthria hookeri (Velvet Bean/Bug catcher)
Pycnostachys urticifolia (Hedgehog Sage)
Rhus dentata (Nana berry)
Satyrium cristatum (lekholela la bana ba seng)
Satyrium longicauda (Long tailed Trewwa)
Senecio glaberrimus
Senecio inornatus (Dan's Cabbage)
Senecio madagascariensis
Tephrosia macropoda (Creeping Tephrosia)
Thunbergia atriplicifolia (Natal Primrose)
Watsonia lepida (Khahla)
Xysmalobium involucratum (Scented Xysmalobium)

Ferns:
Pteridium aquilinum (Bracken)